CLAIMS

What is claimed is:

1. A method for generating an acceleration profile for a valve operating cam of an internal combustion engine, the profile satisfying a plurality of constraints, the method comprising:

generating a valve acceleration versus cam angle draft curve by specifying a plurality of points of desired valve acceleration versus cam angle and using a curve fitting routine to form the draft acceleration curve interconnecting the plurality of points;

developing a set of equations, one for each of the plurality of constraints in terms of parameters of the draft acceleration curve and a plurality of scaling factors, one for each section of the draft curve between roots thereof, and forming a determinant for the set of equations;

selecting at least one point on the draft curve as an adjustment point;

varying the adjustment point to an adjustment acceleration value that forces the determinant to substantially zero;

using the curve fitting routine to generate an adjusted acceleration curve including the adjustment acceleration value;

solving the set of equations for values of the scaling factors as a function of parameters of the adjusted acceleration curve; and

multiplying values in sections of the draft acceleration curve between roots thereof by resultant values of a corresponding scaling factor to generate a constraint satisfied acceleration profile.

2. The method of claim 1 wherein the plurality of constraints comprise:

valve closing lift;

valve closing velocity;

valve maximum lift; and

valve velocity at zero cam angle.

3. The method of claim 1 wherein the adjustment acceleration value is non-zero.

4. The method of claim 3 wherein the at least one adjustment point is selected as the second point past zero degree cam angle in a positive cam angle direction.

5. The method of claim 1 wherein the adjustment acceleration value is derived using Newton's method of root calculation on the determinant.

6. The method of claim 1 wherein a change in the acceleration of the at least one adjustment point to reach the adjusted acceleration value is

determined using a zero-finding routine to make the determinant approach zero to within a predetermined tolerance value.

7. The method of claim 1 wherein the specified plurality of points of desired valve acceleration includes at least five points having distinct cam angles equal to or between zero cam angle and a next root in a positive cam angle direction.

8. The method of claim 7 wherein the at least one adjustment point is selected as a middle point of the five points.

9. The method of claim 1 wherein the curve fitting routine is arranged such that only a portion of the draft acceleration curve is altered when the at least one adjustment point is varied.

10. The method of claim 9 wherein the curve fitting routine is arranged such that the draft acceleration curve is altered only at segments between two curve points on either side of the at least one adjustment point when the at least one adjustment point is varied.

11. The method of claim 1 wherein the curve fitting routine is based on a quadratic function.

12. The method of claim 9 wherein the curve fitting routine is based on a quadratic function.

13. The method of claim 10 wherein the curve fitting routine is based on a quadratic function.

14. The method of claim 8 wherein the curve fitting routine is arranged such that the draft acceleration curve is altered only at segments between two curve points on either side of the at least one adjustment point when the at least one adjustment point is varied.

15. A method for generating an acceleration profile for a valve operating cam of an internal combustion engine wherein the acceleration profile satisfies four valve motion constraints on valve closing velocity, valve closing lift, valve maximum lift and valve velocity at zero cam angle, the method comprising:

generating a valve acceleration versus cam angle draft curve by specifying a plurality of points of desired valve acceleration at a like plurality of cam angles, thereby defining a positive opening acceleration pulse, followed by a negative valve spring acceleration pulse, followed by a positive closing acceleration pulse;

using a curve fitting routine to form the draft acceleration curve interconnecting the plurality of points;

developing a set of four equations, one for each of the four constraints in terms of parameters of the draft acceleration curve and three scaling factors, one for each of the acceleration pulses;

forming a determinant for the set of four equations;

selecting a point on the draft curve as an adjustment point;

varying the adjustment point to an adjustment acceleration value that forces the determinant to substantially zero;

using the curve fitting routine to generate an adjusted acceleration curve including the adjustment acceleration value;

solving the four equations for values of the three scaling factors as a function of the parameters of the adjusted acceleration curve; and

scaling the positive opening, negative valve spring and positive closing acceleration pulses of the adjusted acceleration curve with the first, second and third scaling factors, respectively.

16. The method of claim 15 wherein the specified plurality of points of desired valve acceleration includes five points with cam angle coordinates equal to or between zero cam angle and the end of the negative valve spring acceleration pulse, and wherein the adjustment point is selected as the middle one of the five points.

17. The method of claim 15 wherein the curve fitting routine is based on a quadratic function.

18. The method of claim 16 wherein the curve fitting routine is operative to generate the adjusted acceleration curve differing from the draft acceleration curve only in sections of the adjusted acceleration curve extending between adjacent pairs of the five points.

19. The method of claim 17 wherein the curve fitting routine is operative to generate the adjusted acceleration curve differing from the draft acceleration curve only in sections of the adjusted acceleration curve extending between adjacent pairs of the five points.

20. The method of claim 15 wherein the curve fitting routine is arranged such that only a portion of the draft acceleration curve is altered when the adjustment point is varied.